Space Weather Technical Forecast

Issued on Monday, 24 July 2023 at 01:11 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance R1/R2 blackouts throughout. Chance of G1 peaking 26 into 27 July.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low through the UTC day of Sunday 23 July, with X-ray flares at GOES16 showing a low C-class background, with a peak C9.9 flare from AR3373 at 23/0454UTC. Also observed was a long-period C7.4 at 23/1457UTC, with this associated with a Type IV radio burst and a Coronal Mass Ejection (CME) from AR3376 in the northwest quadrant, possibly capped by an impulsive second flare from AR3380 on the southeast limb.

There are currently up to eight sunspot regions on the Earth-facing disc, with a new small unnumbered bipolar region developing in the southwestern quadrant. The most complex of the current front-side remains AR3373, with a Zurich classification of Fai/Beta-Gamma, although it has lost its potential Mt Wilson delta spot of recent days, and it is now also showing a reduction in penumbral area around its leading group. A similar reduction in complexity was also seen in two of the other main sunspot groups on the disc, AR3372 and AR3379, which now show as a Cho/Beta and Cso/Beta respectively. All other sunspot groups were inactive and magnetically simple.

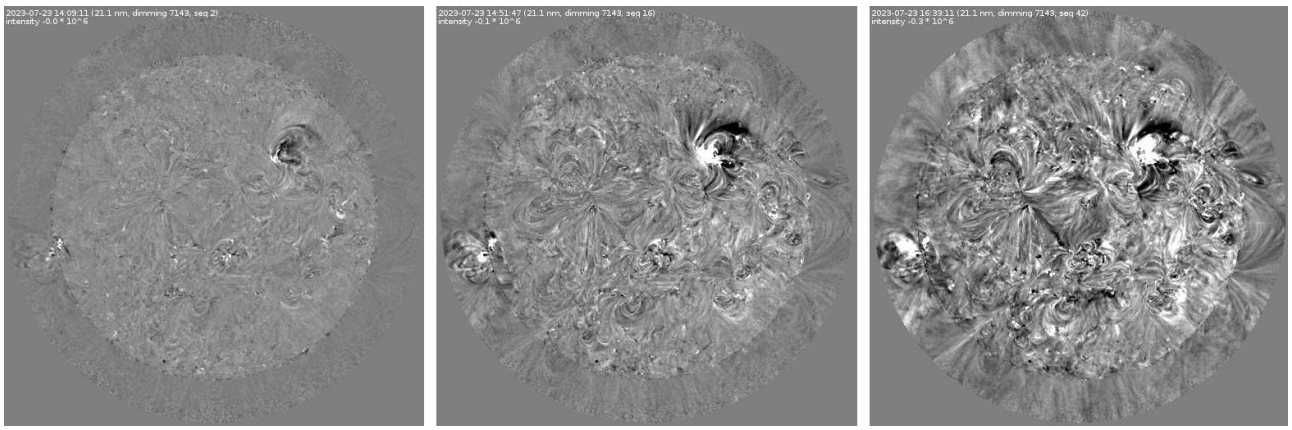

Figure 0: AIA211 time-integrated dimming of the C7.4 flare and CME from the vicinity of AR3376. This CME has been modelled and assessed as having a possible Earth-directed component, with arrival around the turn of the UTC day 26 into 27 July. Image processing courtesy SIDC ROB.

Coronagraph imagery for the UTC day shows an apparently wide-angled but slow northwest-heading CME early in the period that is thought to be far-sided. The aforementioned C7.4-related CME from AR3376 then appears as a partial halo on UTC evening coronagraphs. This feature has been modelled, with a glancing blow possible around the turn of the UTC day 26 into 27 July.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR at L1, suggests

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connection to a weak high speed stream, most likely from coronal hole 26 which is currently indistinct on the southwestern limb. Solar wind speeds were consequently slightly elevated, with a slight downward tendency observed from near 475 to 400km/s. The solar wind density was level and within the long-term average of single figures ppcc, while the IMF was steady at or below 7nT. The north-south component ranged from +4 to -6nT, with a gradual drift from mainly co-aligned to anti-aligned (with Earth's field) observed. The phi angle was negative (towards the Sun).

The net result of the above solar wind measures was for provisionally mainly Quiet geomagnetic activity, with peak Kps of '3-' seen in the 09-12 and 15-18UTC intervals.

Energetic Particles / Solar Radiation: GOES16 high energy proton flux (greater than 10MeV) was at Background levels.

GOES16 high energy (greater than 2MeV) electron flux was mainly at Normal Background levels. 24-hour integrated fluence remained well below the Active threshold, with a slight rising trend to an observed maximum at 24/0001UTC of 4.2e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity carries a daily Chance of isolated M-class flares, most likely from AR3373, which should leave the disc midweek. Far side soundings suggest possible returning regions from around the same time, and as a consequence the flare risk is held constant.

Solar Wind / Geomagnetic Activity: A glancing blow from the 23 July C7.4 CME from AR3376 is possible around the turn of the UTC day of 26 into 27 July. This should bring a Chance of G1 should it affect Earth. Otherwise, a further high speed stream from coronal hole 27 is forecast to connect with the Earth during 24 July.

Mainly Quiet to Unsettled geomagnetic activity is expected, with a Slight Chance of a G1/Minor Storm from coronal hole 27 in the current UTC day, and a Chance of G1 should the CME from AR3376 affect Earth on 26 into 27 July.

Energetic Particles / Solar Radiation: The high energy (greater than 10MeV) proton flux is expected to persist at Background levels, with a daily Slight Chance of an S1+ event, falling slightly as some of the more potent regions begin to rotate away onto the far side from midweek UTC.

The high energy electron flux (greater than 2MeV) is currently at Normal Background levels, with a chance of rising to High at diurnal peaks from day two (Tuesday 25 July), The associated 24-hour fluence carries a Chance of breaching the Active threshold rising by midweek.

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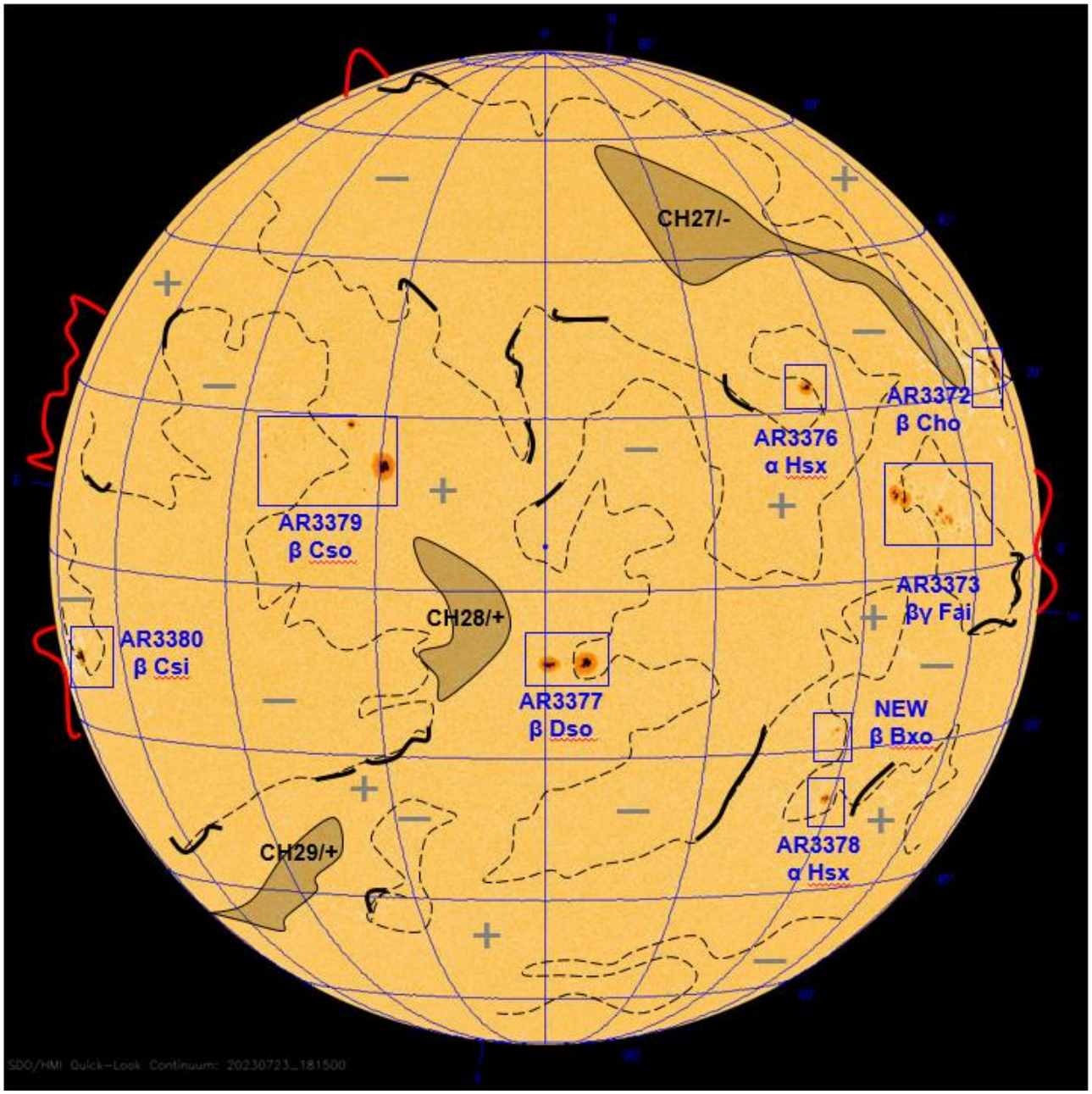
Figure 1. Solar Analysis Valid 23/1815UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

AR3376 produced a long-period C7.4 flare at 23/1457UTC (perhaps contributed to by a concurrent flare from AR3380). This produced a partial halo CME that has been assessed and modelled as presenting a risk of a glancing blow around the turn of the UTC day 26 into 27 July. The main part of the CME is modelled as crossing 1AU around 26/1200UTC, however because a glancing blow from the side lobe of the CME is forecast, a considerable delay is likely, with a most likely arrival of 27/0001UTC +/-6 hours. MOSWOC Enlil is currently providing a reasonable assessment of current solar wind conditions, although it does suggest possible interaction with a CIR - perhaps that from CH28/+ near centre disc. While this aspect lowers confidence as to the magnitude of any impact, no timing adjustment is felt necessary. This is the only CME that features.

Otherwise, slightly elevated solar winds may become further enhanced during 24 July, due to connection with a high speed stream from coronal hole 27 in the northern hemisphere. This produced speeds of around 450-550km/s on the last rotation, with a similar enhancement likely on this occasion. Winds are then forecast to ease through 26 July as these effects wane.

Overall, geomagnetic activity is forecast to be mainly Quiet to Unsettled, with a Slight Chance of a G1/Minor Storm on Monday 24 July from CH27, and a Chance of similar around the turn of the UTC day 26 into 27 July from the AR3376 CME, perhaps slightly bolstered by CH28's CIR.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	1	10	30
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
23/1915	Partial	C7.4 AR3376	NW quadrant	735	27/0001 +/-6 hours	Glancing blow

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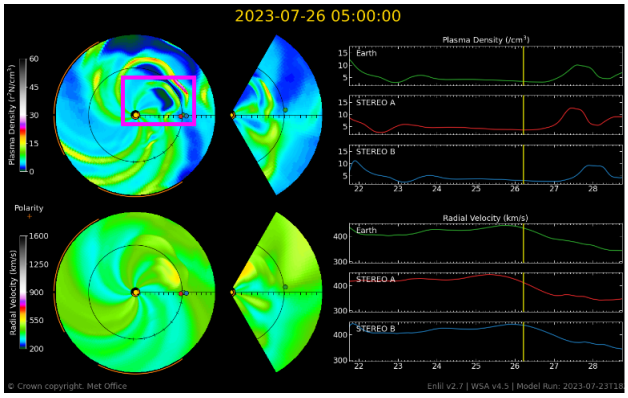
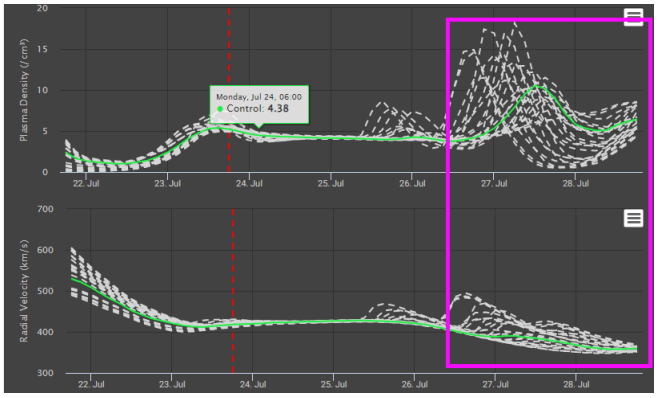
Figure 2: Latest MOSWOC Enlil run and ensemble, showing boxed magneta the possible influence of the 23 July AR3376 CME. Note that the portion near the Sun-Earth line interacts with a high density environment which slows its progress. This may be the CIR from CH28, and may result in a higher density enhancement, although this aspect is low confidence.





Radio Blackouts - X-Ray Flares:

While there are up to eight sunspot groups on the current Earth-facing disc, the majority are either simple and stable, else in slow decay, as appears to be the case with AR3373, AR3372 and AR3379. There has been a trend over recent days away from Zurich D- E- and F- groups towards simpler C- groups, and this has had a knock-on effect on the raw values for flares from the disc - currently rated at a daily Chance of M-class and Slight Chance for X.

Far-side soundings suggest that the bulk of potential active regions lie east of Carrington longitude 090, which is at least two days' rotation away from the eastern limb. While their presence is uncertain (perhaps being plage), these may serve to offset some of the losses over the western limb, Firstly AR3372 by Tuesday 25 July, but most notably AR3373 which should leave the disc by midweek.

All considered, there is a daily Chance of isolated M-class flares, with the most likely source remaining AR3373. Although uncertain, losses over the western solar horizon may be compensated for by arrivals over the east.

X Ray Flares	**Level**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability			**(%)**	**(%)**	**(%)**	**(%)**
Active	**R1-R2 M Class**	No	40	40	40	40
Very Active	**R3 to R5 X Class**	No	5	5	5	5

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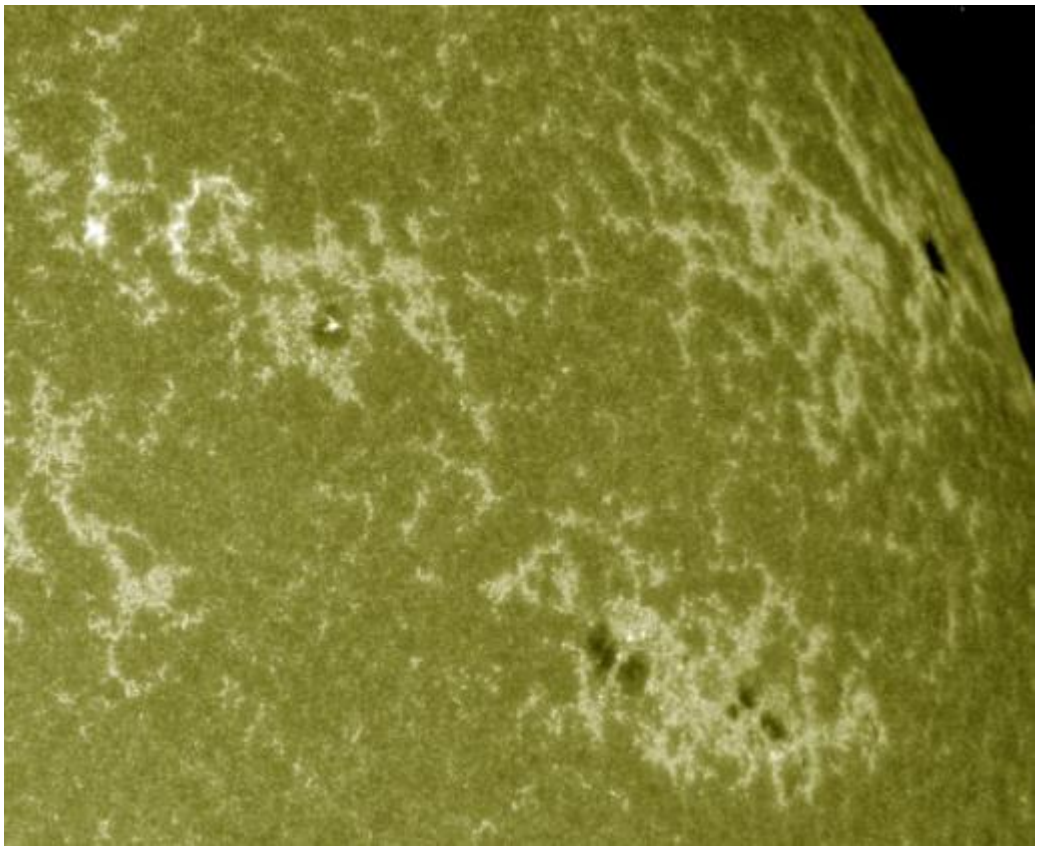
Figure 3: SDO AIA1600 image of AR3376, AR3373 and AR3372 at the time of the C7.4 flare. This can be seen to largely emanate from the plage trailing AR3376, i.e. slightly nearer the Sun-Earth line than the main penumbral spot, perhaps indicating a slightly more geoeffective CME.



Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16, is now at Background levels after recent enhancements.

There is an ongoing Slight Chance of reaching the S1/Minor Radiation Storm threshold should a sizeable flare occur in AR3372 or perhaps more likely AR3373, although the trend in both spots appears to be towards simplification and shrinking. The daily risk of proton events should begin to wane as this pair begin to rotate away onto the far-side in the second half of the coming working week.

Radiation Storms	**Level (cm^{-2} sr^{-1} s^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ S1**	No	10	10	10	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons Event (≥ 2MeV):

High energy electrons (greater than 2MeV) are at mainly Normal Background levels in a modest fast solar wind environment. The forecast upcoming high speed stream from CH27 is likely to lead to a rise in flux levels, with a chance of exceeding the High (1e3pfu) threshold from day two, Tuesday 25 July.

24-hour electron fluence is most likely to remain below the Active (1e8 integrated pfu) threshold throughout the period, although a rising trend is expected. MOSWOC REFM indicates this rising tendency, with the previous rotation eventually seeing narrow exceedence of Active, although due to the slightly damped response to CH26 on this rotation and CH27's diffuse appearance, on balance 24-hour fluence is felt to more likely trend slightly below last pass by midweek.
In addition to the above, any CME influence may dent 24-hour integrated fluence at GEO on day four.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	10	30	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: Top: Past week in GOES16 high energy electron flux, showing current steady state mainly within Normal Background flux. Bottom: the upcoming response from CH27 suggests Active 24-hour integrated fluence is possible, albeit marginal and perhaps slightly below that shown here due to more modest driving (coronal hole) features and an outstanding CME (not shown).

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